PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Hiroyuki KIYOKU *et al.*

Appln. No.: Continuation of 09/603,437 Group Art Unit: 1765

Confirmation No.: To be Assigned Examiner: To be Assigned

Filed:

For: NITRIDE SEMICONDUCTOR GROWTH METHOD, SEMICONDUCTOR SUBSTRATE, AND NITRIDE SEMICONDUCTOR DEVICE

PRELIMINARY AMENDMENT

Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination, please amend the above-identified application as follows:

IN THE SPECIFICATION:

Before the first line of the specification, please insert the following new paragraph:

This is a Continuation of application Serial No. 09/603,437 filed June 23, 2000, now pending, which is a Division of application Serial No. 09/202,141 filed December 9, 1998, now U.S. Patent 6,153,010, which is a 35 U.S.C. § 371 of PCT/JP98/01640 filed April 9, 1998.

Page 5, please delete the first full paragraph, and replace it with the following new paragraph:

In the first and second aspects of the present invention, the first selective growth mask is preferably made up of a plurality of individual or discrete stripes spaced apart from each other,

defining the first windows therebetween, and extending parallel to each other. In addition, in the first and second aspects, the ratio of a width of each of the stripes to a width of each of the first windows is preferably more than 1 and not more than 20. In the first and second aspects, it is especially preferable that the dissimilar substrate be a sapphire substrate having a major surface forming a (0001) plane, and the respective stripes preferably extend in a direction perpendicular to a $(1\bar{1}20)$ plane of sapphire; the dissimilar substrate be a sapphire substrate having a major surface forming a $(1\bar{1}20)$ plane, and the respective stripes extend in a direction perpendicular to the $(1\bar{1}02)$ plane of sapphire; or the dissimilar substrate be a spinnel substrate having a major surface forming a (111) plane, and the respective stripes extend in a direction perpendicular to the (110) plane of spinnel.

Page 13, please delete the first full paragraph, and replace it with the following new paragraph:

Referring to FIG. 1A again, a selective growth mask 13 having a plurality of windows 14a to 14e partly (selectively) exposing the underlayer 12 is formed on the underlayer 12 formed on the dissimilar substrate 11. FIG. 1A shows, as a preferred form, the selective growth mask 13 as being made up of individual or discrete stripes 13a to 13e each having a rectangular cross-section. Referring to FIG. 1A, the spaces between the stripes 13 correspond to the windows 14a to 14e. The windows 14a to 14e will be sometimes generically referred to simply as a window 14 hereinafter.

Please delete the paragraph bridging pages 13-14, and replace it with the following new paragraph:

As shown in FIG. 1B, nitride semiconductor portions 15 are grown from the surface portions, of the underlayer 12, which are exposed from the windows 14a to 14e of the selective growth mask 13 by using a gaseous Group 3 element source and a gaseous nitrogen source according to the present invention. When nitride semiconductor portions are grown on the underlayer 12 whose surface is selectively covered with the selective growth mask 13 (or selectively exposed) in this manner, the nitride semiconductor portions do not grow on the entire surface of the selective growth mask 13 at first, but selectively grow on the portions, of the underlayer 12, which are exposed by the windows 14. When the nitride semiconductor portions further grow and exceed the upper end faces of the mask 13, each nitride semiconductor crystal 15 exceeds a corresponding window 14 and then grows laterally on a corresponding selective growth mask 13. Since the crystal defects in the underlayer 12 are covered with the selective growth mask 13, the crystal defects are not easily dislocated to the portion, of the nitride semiconductor 15, which grows laterally unlike a nitride semiconductor growing vertically like the underlayer 12. In addition, the crystal defects of the underlayer 12 extend laterally as the nitride semiconductor crystal 15 grows on the selective growth mask 13, but tends to stop halfway. Furthermore, some crystal defects dislocated through the window 14 appear on the upper surface of the nitride semiconductor layer, but the crystal defects tend to stop halfway.

Please delete the paragraph bridging pages 22-23, and replace it with the following new paragraph:

FIG. 3 is a view of a unit cell showing the crystal structure of a nitride semiconductor. Strictly speaking, the nitride semiconductor has a rhombic structure, but can be approximated to a hexagonal system in this manner. According to the method of the present invention, a sapphire substrate having the C plane as a major surface is preferably used as the dissimilar substrate 11, and the selective growth mask 13 is preferably made up of a plurality of individual stripes extending parallel in a direction perpendicular to the sapphire A plane (in other words, extending parallel in a direction (the $<1\bar{1}20>$ direction of the nitride semiconductor) parallel to the M plane ($(1\bar{1}00)$ plane) of the nitride semiconductor). That is, in FIG. 4, which is a plane view of the sapphire substrate on the major surface side, the sapphire substrate 11 has the sapphire C plane as the major surface and an orientation flat (ORF) surface as the A plane. As shown in FIG. 4, the selective growth mask 13 is preferably made up of a plurality of individual stripes extending parallel in a direction perpendicular to the sapphire A plane. It should be noted that although FIG. 4 shows only five individual stripes for the sake of easy understanding, more individual stripes are actually formed.

Please delete the paragraph bridging pages 46-47, and replace it with the following new paragraph:

The relationship between the first growth control mask 73 and the dissimilar substrate 11 is preferably equivalent to the previously described relationship between the selective growth mask and the dissimilar substrate 11. Therefore, the items described under the title <Preferable Relationship between Dissimilar Substrate and Selective Growth Mask> equally apply to the first growth control mask 73. More specifically, the first growth control mask 73 is preferably

made up of a plurality of individual stripes each having a substantially rectangular cross-section. In this case, the respective individual stripes are preferably formed on the sapphire C plane to extend parallel in a direction perpendicular to the sapphire A plane, or on the sapphire A plane to extend parallel in a direction perpendicular to the sapphire R plane. Alternatively, the respective individual stripes are preferably formed on the spinnel (111) plane to extend parallel in a direction perpendicular to the spinnel (110) plane. Therefore, the respective recess portions 72 are preferably formed by a plurality of individual grooves extending in the same direction as that of the striped growth control mask 73. The top surface of each wall defined between adjacent grooves preferably has the same plane shape as that of each striped growth control mask 73.

Page 82, please delete the first full paragraph, and replace it with the following new paragraph:

Similar to Example 3, a 200-angstroms thick low-temperature buffer layer made of GaN and a 4-μm thick undoped GaN layer were grown on a sapphire substrate 11 having a C plane as a major surface and an ORF surface forming an A plane so as to form an underlayer 12 having a two-layer structure. First selective growth masks made up of many SiO_2 stripes having a stripe width of 20 μm and a stripe interval of 5 μm were grown on the undoped GaN layer to a thickness of 0.1 μm by using a CVD apparatus. The first selective growth masks extended parallel in a direction perpendicular to the ORF surface.

IN THE CLAIMS:

Please cancel claims 5, 7, 13-15, 18-22, 24, 26-47, 50-176, and 186 without prejudice or disclaimer.

Please enter the following amended claims:

23. (Amended) A method according to claim 1, wherein growth of the first nitride semiconductor portion in the step (b) is performed by a metalorganic vapor-phase epitaxial method.

184. (Amended) A nitride semiconductor device comprising a nitride semiconductor device structure supported on said nitride semiconductor substrate as defined in claim 177.

Please add the following new claims:

187. (New) A nitride semiconductor laser diode device comprising a nitride semiconductor substrate, and a laser diode element provided over said nitride semiconductor substrate, wherein said nitride semiconductor substrate has been prepared by (a) forming a first selective growth mask on a support member comprising (i) a dissimilar substrate made of a material different from a nitride semiconductor and having a major surface, and (ii) an underlayer made of nitride semiconductor formed over the major surface of said dissimilar substrate, said first selective growth mask having a plurality of first windows selectively exposing an upper surface of said underlayer of the support member; and (b) growing nitride semiconductor portions from the upper surface portions, of the underlayer, which are exposed from said windows, by using a gaseous Group 3 element source and a gaseous nitrogen source, until the nitride semiconductor portions grown in the adjacent windows combine with each other

on the upper surface of said selective growth mask, to provide said nitride semiconductor substrate.

188. (New) The device of claim 187, wherein said laser diode element comprises an active layer made of a nitride semiconductor material, which is provided between a p-type clad layer made of a p-type nitirde semiconductor material and an n-type clad layer made of an n-type nitirde semiconductor material.

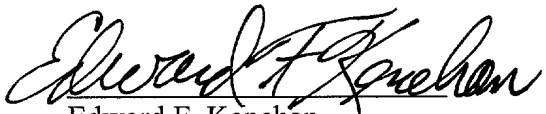
REMARKS

Claims 1-4, 6, 8-12, 16, 17, 23, 25, 48, 49, 177-185, 187, and 188 are pending. This Preliminary Amendment cancels claims 5, 7, 13-15, 18-22, 24, 26-47, 50-176, and 186, amends claims 23 and 184, and adds claims 187-188.

The specification is amended to correct obvious typographical errors and obvious errors of crystallography nomenclature. No new matter is added.

Entry and consideration of this Amendment are respectfully requested.

Respectfully submitted,



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APPENDIX

Version With Markings To Show Changes Made

IN THE SPECIFICATION:

The specification is changed as follows:

Page 5, first full paragraph:

In the first and second aspects of the present invention, the first selective growth mask is preferably made up of a plurality of individual or discrete stripes spaced apart from each other, defining the first windows therebetween, and extending parallel to each other. In addition, in the first and second aspects, the ratio of a width of each of the stripes to a width of each of the first windows is preferably more than 1 and not more than 20. In the first and second aspects, it is especially preferable that the dissimilar substrate be a sapphire substrate having a major surface forming a (0001) plane, and the respective stripes preferably extend in a direction perpendicular to a $(11\bar{2}0)$ plane of sapphire; the dissimilar substrate be a sapphire substrate having a major surface forming a $(11\bar{2}0)$ plane, and the respective stripes extend in a direction perpendicular to the [$(1\bar{1}20)$] $(1\bar{1}02)$ plane of sapphire; or the dissimilar substrate be a spinnel substrate having a major surface forming a (111) plane, and the respective stripes extend in a direction perpendicular to the (110) plane of spinnel.

Page 13, first full paragraph:

Referring to FIG. 1A again, a selective growth mask 13 having a plurality of windows 14a to [14d] 14e partly (selectively) exposing the underlayer 12 is formed on the underlayer 12

formed on the dissimilar substrate 11. FIG. 1A shows, as a preferred form, the selective growth mask 13 as being made up of individual or discrete stripes 13a to 13e each having a rectangular cross-section. Referring to FIG. 1A, the spaces between the stripes 13 correspond to the windows 14a to [14d] 14e. The windows 14a to [14d] 14e will be sometimes generically referred to simply as a window 14 hereinafter.

Paragraph bridging pages 13-14:

As shown in FIG. 1B, nitride semiconductor portions 15 are grown from the surface portions, of the underlayer 12, which are exposed from the windows 14a to [14d] 14e of the selective growth mask 13 by using a gaseous Group 3 element source and a gaseous nitrogen source according to the present invention. When nitride semiconductor portions are grown on the underlayer 12 whose surface is selectively covered with the selective growth mask 13 (or selectively exposed) in this manner, the nitride semiconductor portions do not grow on the entire surface of the selective growth mask 13 at first, but selectively grow on the portions, of the underlayer 12, which are exposed by the windows 14. When the nitride semiconductor portions further grow and exceed the upper end faces of the mask 13, each nitride semiconductor crystal 15 exceeds a corresponding window 14 and then grows laterally on a corresponding selective growth mask 13. Since the crystal defects in the underlayer 12 are covered with the selective growth mask 13, the crystal defects are not easily dislocated to the portion, of the nitride semiconductor 15, which grows laterally unlike a nitride semiconductor growing vertically like the underlayer 12. In addition, the crystal defects of the underlayer 12 extend laterally as the nitride semiconductor crystal 15 grows on the selective growth mask 13, but tends to stop

halfway. Furthermore, some crystal defects dislocated through the window 14 appear on the upper surface of the nitride semiconductor layer, but the crystal defects tend to stop halfway.

Paragraph bridging pages 22-23:

FIG. 3 is a view of a unit cell showing the crystal structure of a nitride semiconductor. Strictly speaking, the nitride semiconductor has a rhombic structure, but can be approximated to a hexagonal system in this manner. According to the method of the present invention, a sapphire substrate having the C plane as a major surface is preferably used as the dissimilar substrate 11, and the selective growth mask 13 is preferably made up of a plurality of individual stripes extending parallel in a direction perpendicular to the sapphire A plane (in other words, extending parallel in a direction (the $[<1\bar{1}00>]$ $\underline{<11\bar{2}0>}$ direction of the nitride semiconductor) parallel to the M plane ($(1\bar{1}00)$ plane) of the nitride semiconductor). That is, in FIG. 4, which is a plane view of the sapphire substrate on the major surface side, the sapphire substrate 11 has the sapphire C plane as the major surface and an orientation flat (ORF) surface as the A plane. As shown in FIG. 4, the selective growth mask 13 is preferably made up of a plurality of individual stripes extending parallel in a direction perpendicular to the sapphire A plane. It should be noted that although FIG. 4 shows only five individual stripes for the sake of easy understanding, more individual stripes are actually formed.

Paragraph bridging pages 46-47:

The relationship between the first growth control mask 73 and the dissimilar substrate 11 is preferably equivalent to the previously described relationship between the selective growth

mask and the dissimilar substrate 11. Therefore, the items described under the title <Preferable Relationship between Dissimilar Substrate and Selective Growth Mask> equally apply to the first growth control mask 73. More specifically, the first growth control mask 73 is preferably made up of a plurality of individual stripes each having a substantially rectangular cross-section. In this case, the respective individual stripes are preferably formed on the sapphire C plane to extend parallel in a direction perpendicular to the sapphire [C] A plane, or on the sapphire A plane to extend parallel in a direction perpendicular to the sapphire R plane. Alternatively, the respective individual stripes are preferably formed on the spinnel (111) plane to extend parallel in a direction perpendicular to the spinnel (110) plane. Therefore, the respective recess portions 72 are preferably formed by a plurality of individual grooves extending in the same direction as that of the striped growth control mask 73. The top surface of each wall defined between adjacent grooves preferably has the same plane shape as that of each striped growth control mask 73.

Page 82, first full paragraph:

Similar to Example 3, a 200-angstroms thick low-temperature buffer layer made of GaN and a 4-μm thick undoped GaN layer were grown on a sapphire substrate 11 having a C plane as a major surface and an ORF surface forming an A plane so as to form an underlayer 12 having a [tow-layer] two-layer structure. First selective growth masks made up of many SiO_2 stripes having a stripe width of 20 μm and a stripe interval of 5 μm were grown on the undoped GaN layer to a thickness of 0.1 μm by using a CVD apparatus. The first selective growth masks extended parallel in a direction perpendicular to the ORF surface.

IN THE CLAIMS:

Claims 5, 7, 13-15, 18-22, 24, 26-47, 50-176, and 186 are canceled.

The claims are amended as follows:

23. (Amended) A method according to claim [18] 1, wherein growth of the first nitride semiconductor portion in the step (b) is performed by a metalorganic vapor-phase epitaxial method.

184. (Amended) A nitride semiconductor device comprising a nitride semiconductor device structure supported on said nitride semiconductor substrate as defined in [any one of claims] claim 177 [to 183].

Claims 187 and 188 are added as new claims.